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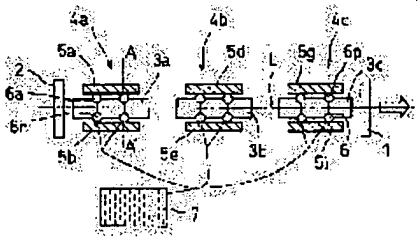
(54) SOLID-STATE LASER DEVICE AND LASER PROCESSING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a laser device, together with a laser processing device using it, where, being as a solid-state laser device of multi-rod method, excitation modules are balanced for well oscillation.
SOLUTION: Around solid-state laser media 3a, 3b, and 3c separated each other, a plurality of monitor means 6a, and 6b-6r are provided to detect fluorescence emitted from the solid-state laser media 3a, 3b, and 3c.



LEGAL STATUS

[Date of request for examination]

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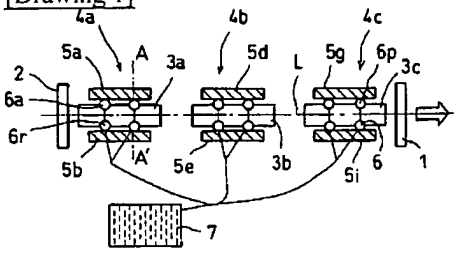
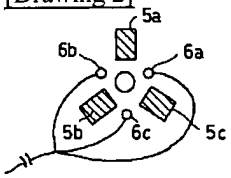
DRAWINGS

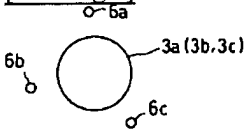
[Drawing 1]



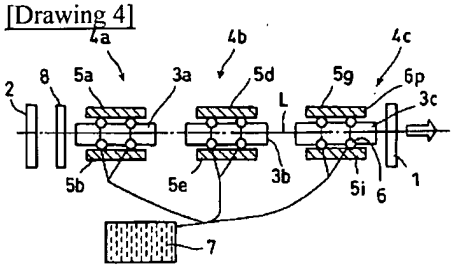
[Drawing 2]



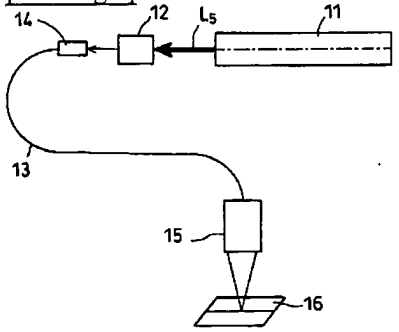
[Drawing 3]



[Drawing 4]



[Drawing 5]



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the solid-state-laser equipment which carries out optical pumping of the solid-state-laser medium, and is made to generate a laser beam, and the laser-beam-machining equipment using it.
[0002]
[Description of the Prior Art] Generally, solid-state-laser equipment was equipped with the laser rod as a solid-state-laser medium, and the laser beam is generated by carrying out optical pumping of this racer rod with excitation means, such as a lamp and LD (laser diode). Therefore, if a laser rod is arranged in an optical resonator, it is amplified by the optical resonator, and the laser beam generated from this laser rod will oscillate, and will be outputted.
[0003] In such solid-state-laser equipment, in order to take out a big laser output, the multi-rod method which arranges two or more laser rods in a serial is adopted in an optical resonator. For example, in the technology indicated by JP,8-250797,A, two or more laser rods are arranged to a serial in an optical resonator, and the method of taking out a quality laser beam by high power is indicated. In addition, in order to compensate the heat birefringence effect in a laser rod, the phase-conjugation-optics system is inserted into the resonator here.
[0004] Moreover, with the technology indicated by the utility model No. 2524199 official report, in order to take out a high power laser beam, the resonator of the multi-rod method which has arranged two or more laser rods to the serial is indicated. Here, by making some curvatures of a laser rod into a concave surface, it is devised so that the stable output may be taken out.

[0005]
[Problem(s) to be Solved by the Invention] With solid-state-laser equipment, since the laser rod for laser beam generating is heated and the temperature becomes high with excitation energy, based on generating of a differential thermal expansion, change of the refractive index by internal stress, etc., the phenomenon of the thermal lensing effect which has the property of a convex lens optically tends to happen. Especially by the multi-rod method which has arranged two or more laser rods to the serial, the pass of the laser beam between each laser rod comes to have angle of refraction to an optical axis, and, thereby, the predetermined function as an optical resonator is no longer obtained.
[0006] Therefore, in order to take out the laser beam of high power from a multi-laser rod, it is always necessary to adjust the balance of the thermal lensing effect of each laser rod and the excitation module formed with the excitation means, and to make regularity the thermal lensing effect of each excitation module.
[0007] Especially when using LD for the excitation means of an excitation module, that the balance of the thermal lensing effect of an excitation module collapses occurs according to the difference of deterioration of LD each with time, and the function as a good optical resonator is no longer obtained.
[0008] Since each of technology indicated by above-mentioned JP,8-250797,A about this and technology indicated by the utility model No. 2524199 official report is the technology on condition of the excitation means itself balancing normally and acting, the consideration to collapse of the balance generated in aging of an excitation means is not made. Therefore, to aging of these excitation means, it cannot fully be coped with.
[0009] This invention is made based on these situations, it is a thing, is solid-state-laser equipment of a multi-rod method, and aims at offering the laser equipment which maintains the balance of each excitation module and performs a good oscillation, and the laser-beam-machining equipment using it.
[0010]
[Means for Solving the Problem] According to the means by invention of claim 1, it is solid-state-laser equipment characterized by forming two or more monitor means for detecting fluorescence emitted from said solid-state-laser medium in the perimeter which said solid-state-laser medium estranged in solid-state-laser equipment which carries out optical pumping with two or more laser diodes which have estranged and arranged a solid-state-laser medium to the perimeter.
[0011] Moreover, according to the means by invention of claim 2, it is solid-state-laser equipment which ****** being constituted so that current of said laser diode may be adjusted based on a detection result of fluorescence from said monitor means and the amount of optical pumping may be controlled.
[0012] Moreover, according to the means by invention of claim 3, said solid-state-laser medium is solid-state-laser equipment characterized by equipping more than one and being arranged by serial.

[0013] Moreover, according to the means by invention of claim 4, it is solid-state-laser equipment characterized by being constituted so that two or more amounts of optical pumping of said solid-state-laser medium each currently arranged by serial may become equal.
[0014] Moreover, according to the means by invention of claim 5, said monitor means is solid-state-laser equipment characterized by using a photodiode.
[0015] Moreover, according to the means by invention of claim 6, said solid-state-laser medium is solid-state-laser equipment characterized by being a YAG rod.
[0016] Moreover, according to the means by invention of claim 7, it is laser-beam-machining equipment characterized by using above solid-state-laser equipment for laser equipment.
[0017] In addition, fluorescence means a thing of light emitted when an electron changes from an excitation state to a ground state in the invention in this application at a wide sense.
[0018]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.
[0019] By the excitation module of solid-state-laser equipment, the artificer is checking that the laser excitation quantity of light is proportional to the fluorescence from a laser rod. Therefore, if the amount of fluorescence from each hoop direction of a laser rod is equal, it can check that the excitation quantity of light from a laser rod is equally distributed over the perimeter centering on an optical axis. Thereby, it can check whether the laser rod is influenced of the thermal lensing effect.
[0020] To detection of the amount of fluorescence from each hoop direction of a laser rod, it is detectable by arranging PD (photodiode) in the predetermined part around a laser rod.
[0021] On the other hand, deterioration has generated the usual LD from 10,000 hours in about 20,000 hours. Since the laser rod which has not been influenced of the thermal lensing effect will also be influenced of a thermal lensing effect with time in the state of the beginning, therefore, in this invention It is monitored continuously and it grasps correctly, and LD which deteriorated is exchanged, it is coped with [the current value to each LD from LD power supply is controlled, and], excitation distribution in a laser rod is made into homogeneity, and excitation of a laser rod forms the excitation module without a bias.
[0022] These can adjust the bias of the excitation about an independent excitation module.
[0023] Moreover, when two or more excitation modules are connected to a serial and the laser equipment of high power is constituted, the excitation distribution in a laser rod can be adjusted to homogeneity for each excitation module of every, balance adjustment further between excitation modules can be performed, and the solid-state-laser equipment of high power can be obtained.
[0024] Drawing 1 is the ** type side elevation showing the configuration of the solid-state-laser equipment which connected to the serial two or more excitation modules twisted to LD excitation which shows the gestalt of operation of this invention. Moreover, drawing 2 is the A-A'front view.
[0025] The excitation modules 4a, 4b, and 4c equipped with the laser rods 3a, 3b, and 3c which are three YAG rods on the optical axis L between the output mirrors 1 and total reflection mirrors 2 in which solid-state-laser equipment forms an optical resonator are arranged at the serial. LD 5a, 5b-5i which is three excitation means at intervals of 120 degrees, and PD which is an excitation monitor are arranged in the location where the periphery of each laser rods 3a, 3b, and 3c estranged these excitation modules 4a, 4b, and 4c, respectively. In addition, each LD 5a, 5b-5i and each PDs 6a, 6b-6i are arranged by the physical relationship of the phase of every 60 degrees, respectively. Each LD 5a, 5b-5i is connected to LD 5a and 5b - 5i power supplies. Moreover, the light filter (un-illustrating) which absorbs the wavelength of a light field is prepared in the light-receiving side side of PDs 6a, 6b-6r.
[0026] by these configurations, the laser rods 3a, 3b, and 3c excite by LD 5a, 5b-5i connected to the LD power supply 7 from the three directions of the perimeter -- having -- the excitation light -- an optical resonator -- it is amplified, oscillates and is outputted from the output mirror 1.
[0027] PDs 6a, 6b-6r which are excitation monitors are arranged in the three directions of the perimeter of the laser rods 3a, 3b, and 3c, and have detected the fluorescence emitted from the laser rods 3a, 3b, and 3c. By the detection, the monitor of the laser rods 3a and 3b and the amount of excitation of 3c13 is carried out. Moreover, data processing of the signal acquired from PDs 6a, 6b-6r is carried out by an operation and the control section (un-illustrating), and the amount of excitation of LD 5a, 5b-5i is adjusted so that the heat lens of each laser rods 3a, 3b, and 3c may become homogeneity.
[0028] Drawing 3 is a conceptual diagram at the time of carrying out the monitor of the bias of excitation of laser rod 3a, and (3b, 3c) from three directions. For example, when the bias as shown in excitation distribution of laser rod 3a at drawing 3 has arisen, the light income of the monitor by each PDs 6a, 6b, and 6c differs. That is, the light income of PDs 6a and 6b increases more than the light income of PD6c. Thereby, the monitor of the uneven excitation distribution in laser rod 3a can be carried out.
[0029] Excitation distribution in laser rod 3a can be made into homogeneity by controlling the current value to each LD 5a, 5b, and 5c from the LD power supply 7, and adjusting the amount of excitation of LD 5a, 5b, and 5c from this monitor result, so that the output value of each monitor may become equal.
[0030] Next, in order to take out a high power laser beam from the multi-laser rods 3a, 3b, and 3c, it is necessary to make regularity the thermal lensing effect of each excitation modules 4a, 4b, and 4c. Therefore, the balance of the thermal lensing effect of each excitation modules 4a, 4b, and 4c is adjusted. The total value of the output value of the monitor by PDs 6a, 6b-6r in each excitation modules 4a, 4b, and 4c or average value is between each excitation modules 4a and 4b and 4c, and

adjustment of this balance can be realized by adjusting the amount of excitation so that it may become equal.
[0031] In addition, adjustment of the amount of excitation of LD 5a, 5b-5i is performed by controlling the current value to each LD 5a, 5b-5i from the LD power supply 7. These enable it to take out a high power laser beam from laser equipment with a well head.
[0032] In addition, what is necessary is to form a shutter 8 on the optical axis of an optical resonator, and for a monitor just to detect to the timing to which the oscillation at the time of closing a shutter 8 is not performed, as shown in drawing 4 in order to detect more the fluorescence emitted from the laser rods 3a, 3b, and 3c to a precision. In addition, since drawing 4 adds a shutter 8 to drawing 1 , the same sign as drawing 1 shows the same functional part, and omits the explanation of each.
[0033] As mentioned above, the stable high power laser beam can be taken out by carrying out the monitor of the heat lens operation of the laser rods 3a, 3b, and 3c, and adjusting the excitation input of two or more laser rods 3a, 3b, and 3c based on the result.
[0034] In addition, although the YAG laser rods 3a, 3b, and 3c were used as above-mentioned laser rods 3a, 3b, and 3c, other solid-state-laser media, such as a ruby rod, can also be used.
[0035] Moreover, although the configuration of the above-mentioned laser rods 3a, 3b, and 3c was cylindrical, it can apply the preparation of this invention similarly to slab laser.
[0036] Next, the laser-beam-machining equipment using the laser equipment of this invention is explained.
[0037] Drawing 5 is the mimetic diagram of laser-beam-machining equipment which used the laser equipment of this invention. The lens 12 for optical fiber incidence is arranged in the predetermined part on the optical axis of the output side of the laser oscillation machine 11 constituted by above-mentioned laser equipment. The end face of an optical fiber 13 is being fixed to the location of the focus of this lens 12 for optical fiber incidence by the optical fiber fixed unit 14. Moreover, the processing arm head 15 equipped with the condenser lens for processing (un-illustrating) is connected to the other end of an optical fiber 13.
[0038] With these configurations, the laser beam L5 emitted from the laser oscillation machine 1 can perform predetermined thermoforming (for example, welding, cutting, or hardening etc.) to a worked object 16 by irradiating the predetermined part of a worked object 16.
[0039]
[Effect of the Invention] According to this invention, the laser equipment of the high power stabilized with time and the laser-beam-machining equipment using it can be formed.

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Solid-state-laser equipment characterized by forming two or more monitor means for detecting fluorescence emitted from said solid-state-laser medium in the perimeter which said solid-state-laser medium estranged in solid-state-laser equipment which carries out optical pumping with two or more laser diodes which have estranged and arranged a solid-state-laser medium to the perimeter.
[Claim 2] Solid-state-laser equipment according to claim 1 which ****** being constituted so that current of said laser diode may be adjusted based on a detection result of fluorescence from said monitor means and the amount of optical pumping may be controlled.
[Claim 3] Said solid-state-laser medium is solid-state-laser equipment according to claim 1 or 2 characterized by equipping more than one and being arranged by serial.
[Claim 4] Solid-state-laser equipment according to claim 3 characterized by being constituted so that two or more amounts of optical pumping of said solid-state-laser medium each currently arranged by serial may become equal.
[Claim 5] Said monitor means is solid-state-laser equipment according to claim 1 or 3 characterized by using a photodiode.
[Claim 6] Said solid-state-laser medium is solid-state-laser equipment according to claim 1 or 3 characterized by being a YAG rod.
[Claim 7] Laser-beam-machining equipment characterized by using solid-state-laser equipment given in laser equipment at any 1 term of claim 1 thru/or claim 6.

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